

INTERMODALITY PERCEPTION

by

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This study was designed to examine the effects of practice on the perception of repeating temporal patterns.

Stimulus Patterns

The stimulus patterns used were repeating sets of eight dichotomous elements. The dichotomous elements were stimuli presented either to S's left side (L) or to S's right side (R). A pattern can be started at any one of the pattern elements, but since the patterns are continuously repeated, all these patterns are logically equivalent, in that all of the patterns generate the same sequence except for the first few elements. However, they are not perceptually equivalent. Royer and Garner (1966) found that Ss organize and describe patterns by starting at particular elements in the pattern (preferred start points) regardless of the actual start point of the pattern. Patterns are normally organized starting at a series of identical elements (e.g., LLLL) or at a series of alternating elements (e.g., LRLR). Moreover, patterns started at the actual preferred start point are easier to identify than patterns started at actual non-preferred start points. (Garner and Gottwald, 1968)

Pattern Presentation

Five methods of presenting the patterns were used; in the first three methods, the pattern could be identified using only one modality, but in the remaining two methods, information in two modalities must be combined to perceive the pattern.

Using the first method of presentation (Individual) the patterns are presented in a single modality, either the auditory, tactual or visual. In the second method (Compatible Simultaneous), a pattern is presented simultaneously in two modalities so that if a left element appears in one modality, a left element also appears in the second modality. The S can use either modality or the pair of modalities to identify and organize the pattern. In the third

method of pattern presentation (Incompatible Simultaneous), a pattern is presented simultaneously, but reversed, in two modalities so that when a left element is presented in one modality, a right element is presented in the second modality. In this case, the patterns are informationally compatible, although the pattern elements and organizations are spatially incompatible. This method of presentation is a case of stimulus-stimulus incompatibility as separate from stimulus-response incompatibility previously studied (Fitts & Seeger, 1953). In the last two methods of presentation the pattern is given in alternate modalities so that four of the eight elements of a pattern are presented in one modality and the remaining four elements in the second modality. For example, the pattern LLRRLRLR could be represented in the sequence-left light, left light, right light, right light, left tone, right tone, left tone, right tone. In the fourth method, Modality Alternation (4), the modalities alternate every four elements, and in the fifth method, Modality Alternation (2) the modalities alternate every two elements.

Incompatible simultaneous presentation and modality alternation presentation represent extremes in the demands on using information from two modalities. In the former case, the emphasis is on the ability of two senses to operate independently; either modality or the pair of modalities can be used to identify the pattern, but only one modality can be used to describe the pattern. In the latter case, the emphasis is on the ability to shift between modalities and then to synthesize this information; both modalities must be used to identify the patterns.

Previous work (Handel and Buffardi, in preparation) have found, using naive SS, differences among methods of pattern presentation. The aim of this study is to investigate the effect of practice on pattern identification and organization for each method of presentation.

Method

Subjects

There were eight Ss; three males and five females. Six Ss were undergraduates and two were graduate students. Each S was paid \$1.50 per session.

Apparatus

Modalities.--The two stimuli for each modality were perceptually different; one placed on S's left side and the other placed on S's right side. The visual stimuli were a red and a green panel light mounted 1 foot apart on a board about 4 feet in front of S. The auditory stimuli were a 1200 Hz. and a 3000 Hz. tone presented by loudspeakers 6 feet apart and 4 feet in front of S. The tactual stimuli were two Sherrick vibrators (1965), one held in each hand, 1 foot apart. One vibrator was powered by a 12 V., 60 Hz. source and the other vibrator was powered by a 6 V., 30 Hz. source.

Stimulus presentation.--The stimuli were controlled by a tape reader (Western Union 1B) which activated a set of relays to switch the stimuli on and off. Toggle switches controlled the choice of modalities. Two timers (Hunter, Model 111C) were used to time the sequence and trigger the tape reader. A counter recorded the number of elements presented.

The S was placed in a soundproof room. The E observed S through a one-way mirror and communicated with him by intercom system.

Task

The S observed the pattern until he thought he knew the pattern. Then, S stopped the presentation by pressing a foot switch and attempted to describe the pattern verbally by stating the left-right sequence. If the description was incorrect, the pattern continued from the point where it was stopped. If the description was correct, the next pattern was presented. If the pattern was not correctly described after 560 pattern elements were presented, the

next pattern was presented.

Experimental Conditions

Rate of presentation.--Two rates of presentation were used; one or three elements per second. At each rate of presentation, each element appeared for the first one-third of the inter-element interval. Thus, at the rate of three elements per second, each element lasted 111 msec. and the interval between elements was 222 msec.

Start point.--Two start points, determined from Royer and Garner (1966), were used with each pattern. The preferred start point was at an element which Ss often used to organize the pattern and which also led to fast identification of the pattern. The non-preferred start point was at an element rarely used by Ss to organize the pattern and which led to slow identification of the pattern.

Patterns.--Six experimental patterns were used throughout the entire experiment. In addition, three extra patterns were used only during the first five sessions and the last five sessions. The patterns at both start points are shown in Table 1.

Pattern presentation methods.--Five pattern presentation methods were used: individual modality, compatible simultaneous, incompatible simultaneous, modality alternation (2), and modality alternation (4).

If a pattern was presented in an individual modality, the pattern was presented in either the auditory, tactual, or visual modality. If a pattern was presented in a pair of modalities (the remaining four methods of pattern presentation), it was presented in either the auditory-tactual, auditory-visual, or tactual-visual combination.

Experimental Design

The entire experiment consisted of 30 sessions. Within a block of 10 sessions all the experimental conditions were presented once so that the

Table 1

The Patterns used, with Preferred and Non-Preferred Start Points

Patterns	Start Point	
	Preferred	Non-Preferred
Experimental	LLRLRLR	LRLLRLRL
	LLLRLRR	LLRLRLRL
	LLLRRRLR	LLRLRLRL
	LRRLRLR	LRRLRLRL
	LLRRLLR	LLRRLRL
	LRRLRLR	LRRLRLRL
Extra	LLRLRLR	LRRLRLRL
	LLLRLLR	LLRLRLRL
	LLRLRLR	LRRLRLRL

entire experiment consisted of three replications of the experimental conditions.

In one session, S was presented 36 patterns. Patterns were grouped by twelves and each group was presented by one of three different pattern presentation methods. The six patterns were presented twice, once at each rate of presentation and start point. In the first five sessions and in the last five sessions, Ss were presented the extra patterns. Each extra pattern was presented two times by each of the three pattern presentation methods in every session; once at each rate of presentation and start point. Therefore, 18 extra patterns were presented and a total of 54 patterns were presented during these sessions.

The order of presentation of all experimental conditions was counter-balanced across Ss for each block of 10 sessions. For each block of five sessions, all experimental conditions were presented to 4 Ss.

Each pattern and its complement (the complement of LRRRLRLR is RRRLLRRL) were presented an equal number of times and when using alternation presentation, one modality presented each segment of the pattern equally often. Neither of these controls affected pattern identification or organization so that the results have been combined.

Results

Pattern Identification

The measure of performance was the number of elements presented until the pattern was correctly identified (delay). The median delay was found for each pattern at each experimental condition. An analysis of variance indicated that the only significant interactions are due to changes in the rate of presentation. Increasing the rate of presentation has the effect of making hard conditions extremely difficult and increasing the difficulty of easy conditions

only slightly. These interactions are monotonic; the rank order of difficulty of the conditions does not change. Therefore, the median delay of each pattern was averaged over patterns and modalities. Other summary statistics (geometric means, arithmetic means, standard deviations) produced equivalent results.

Start point and rate of presentation.--The delays, averaged across patterns and methods of pattern presentation, for each start point x rate of presentation combination as a function of practice are shown in Table 2.

The effect of practice was to reduce the difference in performance. During the first five sessions, the mean delay at the easiest condition (preferred start point-1 element per second) was 16 elements and the delay at the hardest condition (non-preferred start point-3 elements per second) was 88 elements. During the last ten sessions, the difference between these conditions was only 13 elements. However, the rank order of difficulty of the Start Point x Rate of Presentation conditions remains constant.

Pattern presentation methods.--The delays, averaged across start points, rates of presentation, and modalities or modality pairs of each method of pattern presentation as a function of practice are shown in Table 3.

For every block of five or ten sessions, there were reliable differences between pattern presentation methods. During the first five sessions, when Ss were naive, a series of t tests ($d.f.=4$) indicated that incompatible simultaneous presentation produced the best performance. There was no difference in performance between the individual modality, compatible simultaneous, or successive alternation (4) methods. Successive alternation (2) produced the poorest performance.

By the second block of five sessions and for the remaining sessions, there were no reliable differences between the best three methods: individual modality, compatible simultaneous and incompatible simultaneous. Successive

Table 2

The Average Delay until Pattern Identification for each
Start Point Rate of Presentation Combination

Experimental Sessions	Rate of Presentation			
	Slow		Fast	
	(One Element per Sec.)		(Three Elements per Sec.)	
	Preferred Start Point	Non-Preferred Start Point	Preferred Start Point	Non-Preferred Start Point
1-5	16	25	49	88
6-10	11	15	24	49
11-20	10	13	18	29
21-30	9	11	15	22

Note: The delays are averaged across methods of pattern presentation.

Table 3

Average Delay until Pattern Identification for
each Method of Pattern Presentation

Experimental Sessions	Method of Pattern Presentation				
	Individual Modality	Compatible Simultaneous	Incompatible Simultaneous	Modality Alternation (4)	Modality Alternation (2)
1-5	34	32	24	34	92
6-10	18	15	18	28	44
11-20	15	14	14	20	32
21-30	13	13	13	19	29

Note: The delays are averaged across start points, rates of presentation and modalities.

alternation (4) produced reliably poorer performance than the three easiest methods and the successive alternation (2) reliably produced the poorest performance.

Pattern Organization

Analysis indicated that pattern organizations were similar when patterns were presented by the individual and simultaneous methods and that these differed from organizations when modality alternation methods were used. In addition, rate of presentation did not affect organization.

Preferred start point.--If a pattern began at a preferred start point, the pattern was usually organized beginning at that element. If the patterns were presented using the individual or the simultaneous methods, 88% of the organizations were at the preferred start point during the first five sessions, and increased to 94% by the last five sessions. If the patterns were presented using the modality alternation methods, 90% of the organizations were at the preferred start point during the first five sessions and increased to 99% by the last five sessions.

Non-preferred start point.--For the patterns started at the non-preferred start point, the percentage of organizations at the non-preferred and preferred start points as a function of practice are shown in Table 4.

When patterns were presented using either the individual or simultaneous presentation methods, unpracticed Ss reorganize the pattern; 36% of the organizations were at the actual start point (non-preferred) and 57% of the organizations were at the preferred start point. However, with practice, patterns were increasingly organized at the actual start point; during the last five sessions 79% of the organizations began at the actual start point, previously non-preferred, and 19% of the organizations began at the preferred start point.

Table 4

The Percent of Organizations at
the Non-Preferred and Preferred Start Points
when Patterns began at Non-Preferred Start Points
as a Function of Practice

Experimental Sessions	Method of Pattern Presentation			
	Individual, Compatible Simultaneous and Incompatible Simultaneous Presentation Start Point		Modality Alternation (2) and Modality Alternation (4) Presentation Start Point	
	Non-Preferred	Preferred	Non-Preferred	Preferred
1-5	36	57	77	13
6-10	43	51	65	24
11-15	51	44	68	29
16-20	58	35	59	34
21-25	67	28	57	34
26-30	79	19	63	32

Note: The organizations are averaged across patterns, modalities, and rates of presentation.

If patterns were presented using either modality alternation method, the non-preferred start point is at an element at which modalities alternate but the preferred start point is at an element at which the modalities do not alternate. Therefore, organizations at the non-preferred start point reflect modality organization, not pattern organization, and organizations at the preferred start points reflect organizations based on the properties of the patterns.

With unpracticed Ss, patterns were usually organized at the actual non-preferred start point (77%) and rarely organized the pattern at the preferred start point. With practice, the percentage of organizations at the start point decreased to about 60% and the percentage of organizations at the preferred start point increased until about 33% of the organizations occurred at this element.

Practice. Specific or General?

Performance.--The generality of the effect of practice on pattern identification was assessed by presenting three extra patterns during the first five sessions and again during the last five sessions. If the effect of practice was general, the delay of these patterns should be equal to the delay of patterns presented throughout the experiment. In fact, the performance of both sets of patterns was nearly identical. During the first five sessions, the average delay for the six experimental patterns was 46 elements and the delay for the extra patterns was 42 elements (this difference was not reliable). During the last five sessions, the delay for both sets of patterns was 14 elements.

Organization.--The organization of the extra patterns can also assess the effect of practice. If the effect of practice is general, then the organization of the extra patterns should be similar to the organization of the

experimental patterns during the last five sessions.

If the patterns begin at the non-preferred start point and the patterns are presented by the individual or simultaneous methods, 35% of the organizations were at the non-preferred start points during the first five sessions and 85% were at the non-preferred start points during the last five sessions. If the patterns were presented by the modality alternation methods, 59% of the organizations were at the non-preferred start points during the last five sessions. Thus, organization of the extra patterns is practically identical to the organization of the experimental patterns during the last five sessions.

Discussion

Performance

With unpracticed Ss, the incompatible simultaneous presentation produces the best performance; S-S incompatibility, unlike S-R incompatibility, (Fitts & Seeger, 1953) aids performance. One possible way in which Ss can use the incompatible S-S information is to learn the alternation sequence. For example, the pattern LLRRLRLR can be identified as 2,2,1,1,1,1 and then either "left" or "right" can be substituted in the pattern organization. In addition, with unpracticed Ss, modality alternation (4) is no harder than individual modality or compatible simultaneous presentation. Methods of pattern presentation in which information in two modalities must be integrated does not necessarily produce poorer performance. However, with practice, presentation methods in which a pattern can be identified using one modality are easier than methods in which a pattern information must be integrated.

Organization

The effect of practice is to make perceptual organization more flexible. If patterns begin at non-preferred start points and are presented using the individual or simultaneous methods, practiced Ss organize the pattern at the

actual starting point. The Ss organize at the actual starting point patterns which have been presented often (experimental patterns) and patterns which have been presented only once previously (extra patterns). The Ss have not simply memorized the patterns starting at different elements.

If a pattern begins at a non-preferred start point, and is presented using the modality alternation methods, unpracticed Ss organize by the modality alternations, but practiced Ss begin to organize by the structural properties of the pattern. The pattern had been previously hidden by the modality alternations.

For all methods of pattern presentation, practice leads to different types of pattern organization; either from pattern organization to element organization or from modality organization to pattern organization.

These results provide a rationale for the sensory channel versus type of stimuli organization investigated by Broadbent (1958), Broadbent and Gregory (1964), and Yntema and Trask (1963). Broadbent (1958) demonstrated that two different digits presented simultaneously to the left and right ears are organized by ear, and Yntema and Trask demonstrated that a digit and a word simultaneously presented to the left and right ears are organized by type of item. The Ss in this experiment show both types of organization when patterns are presented using the modality alternation methods. Unpracticed Ss organize by modality (by ears) and practiced Ss organize by pattern (by type of item).

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Abstract

The effect of practice on the perception of temporal patterns presented in the visual, auditory, tactual modalities and combinations of these modalities was investigated. With practice, differences in performance between experimental conditions decrease, but the rank order of difficulty of the conditions was generally consistent. In addition, after practice, pattern organization was more flexible; the structural properties of the pattern no longer dominate organization and Ss can organize by starting at any pattern element. The effect of practice was quite general; patterns used only once previously can be identified as easily as well practiced patterns.